Medical and Veterinary Entomology

*Medical and Veterinary Entomology* (2015), doi: 10.1111/mve.12112

REVIEW ARTICLE

# *Rhipicephalus rossicus*, a neglected tick at the margin of Europe: a review of its distribution, ecology and medical importance

A. D. MIHALCA, Z. KALMÁR and M. O. DUMITRACHE

Department of Parasitology and Parasitic Diseases, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Cluj-Napoca, Romania

**Abstract.** *Rhipicephalus rossicus* (Ixodida: Ixodidae) is a three-host tick with a broad host spectrum that includes wild animals, pets, livestock and humans. Despite its local abundance in certain areas, most of the available information on *R. rossicus* was published decades ago, mainly by former soviet authors. Its distribution largely overlaps the Eurasian steppe. However, its range may be more extensive than is currently known because this species may have been misidentified as *Rhipicephalus sanguineus*, principally in areas where the latter species is present. Although *R. rossicus* has been occasionally reported to feed on people, little attention has been given to its medical importance. It has been shown to have a vectorial role in the transmission of *Francisella tularensis*, Crimean–Congo haemorrhagic fever virus and West Nile virus. However, the vectorial importance of *R. rossicus* may be significantly greater, mainly as the closely related species *R. sanguineus* s.l. is known to transmit a very wide spectrum of pathogens. The probably underestimated vectorial role of *R. rossicus* may represent a hidden public health threat.

**Key words.** *Rhipicephalus rossicus*, Crimean–Congo haemorrhagic fever, seasonal dynamics, tick distribution.

## Introduction

*Rhipicephalus rossicus* Yakimov & Kol-Yakimova, 1911 is a three-host tick with a relatively broad host spectrum that typically inhabits the Eurasian steppe. Despite its local abundance in certain areas, most of the information regarding this tick species was published decades ago, mainly by former soviet authors. Although *R. rossicus* has been reported occasionally as feeding on people, little attention has been given to its medical importance and vectorial role. After comparing the current distribution of *R. rossicus* with 50-year-old records from Ukraine, Akimov & Nebogatkin (2013a) concluded that various human activities, as well as climate change, had ‘driven this species deeply into the north’ of the country. A breeding population was found as far north as Kiev (Nebogatkin, 1996), where this tick is commonly reported on dogs (Akimov & Nebogatkin, 2002, 2013b). Arguably, *R. rossicus* is listed by DAISIE (Delivering Alien Invasive Species Inventories for Europe) as an alien species in Europe (Roy *et al.*, 2011). In view of its territorial expansion and urbanization, as well as recent findings that *R. rossicus* may be the dominant tick species to affect pet animals (Dumitrache *et al.*, 2014; Sándor *et al.*, 2014), the aim of this paper is to present a synoptic review of its taxonomic status, host spectrum, geographical distribution, seasonal dynamics and medical importance.

## Brief taxonomic overview and notes on key morphological features

*Rhipicephalus rossicus* is a tick species of the *Rhipicephalus sanguineus* group. It was initially described as found on

Correspondence: Mirabela Oana Dumitrache, Department of Parasitology and Parasitic Diseases, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Calea Mănăştur 3–5, 400372 Cluj-Napoca, Romania. Tel.: + 40 264 596384; Fax: + 40 264 593792; E-mail: mirabela.dumitrache@usamvcluj.ro

hedgehogs and rats in the governmental district of Saratov, Russia. The immature stages were described by Shatas (1956). Olenev (1928) synonymized it with *R. sanguineus*. Zumpt (1939) considered it to be a subspecies of *R. sanguineus* (*R. sanguineus rossicus*). Currently, it is considered to be a valid species (Kolonin, 2009; Guglielmone *et al.*, 2010). Between 1920 and 1930, various Russian authors divided the *R. sanguineus* group into two different branches: the 'sanguineus branch', and the 'rossicus branch' (Morel & Vassiliades, 1963; Saratsiotis, 1981).

Pomerantzev (1959) considered *R. rossicus* to be morphologically close to *Rhipicephalus pumilio*. This close relationship was also demonstrated genetically by Zahler *et al.* (1997), who performed molecular analysis using ITS2, a conservative marker for the genus *Rhipicephalus*, with low variation between species (Latrofa *et al.*, 2013). This similarity was also highlighted by Beati & Keirans (2001) and suggested conspecificity between the two species. However, other molecular markers (i.e. the mitochondrial 12S of the ribosomal DNA) were demonstrated to be more useful for phylogenetic analyses (Dantas-Torres *et al.*, 2013; Latrofa *et al.*, 2013). Sequences of the 12S rDNA are available for several species of the *R. sanguineus* group (as defined by Walker *et al.*, 2000), including *R. rossicus*. Based on these sequences, we have constructed a phylogenetic tree (Fig. 1) using the maximum parsimony method (Felsenstein, 1985) with the bootstrap test carried out according to the subtree–pruning–regrafting (SPR) algorithm (Nei & Kumar, 2000). The percentage of replicate trees in which the associated taxa are clustered together in the bootstrap test (1000 replicates) was calculated. The phylogenetic branches were supported in $> 50\%$ by bootstrap analysis. Phylogenetic analyses were conducted using MEGA 6 software (Tamura *et al.*, 2013). The phylogenetic analysis based on the 12S rDNA sequence of *R. rossicus* suggests that it forms a paraphyletic group. However, the close relationship of *R. rossicus* with *R. pumilio*, as demonstrated using ITS2 by Zahler *et al.* (1997), is sustained by 12S rDNA.

Because of its close morphological similarities, *R. rossicus* has probably been misidentified in some reports as *R. sanguineus*, mainly in cases of ticks collected from dogs in areas in which the distribution of these two species overlap (Kolomietz, 1936; Dumitrache *et al.*, 2014).

However, most of the references cited in this paper originate from areas outside the distribution range of *R. sanguineus* and hence the possibilities for misidentification are limited. Nevertheless, we cannot verify or exclude such events because no biological material is available and misidentification as other species (i.e. *Rhipicephalus turanicus* or *R. pumilio*) is also possible.

## Host spectrum

The host spectrum of *R. rossicus* is relatively wide (Table 1) and seems to refer to the developmental stage. Overall, *R. rossicus* has been reported to occur on various groups of mammals (rodents, carnivores, ungulates, hedgehogs, shrews, hares, humans), birds (Passeriformes, Galliformes, Falconiformes) and even amphibians. Some host species (shrews, hedgehogs, rodents and hares) are parasitized by all developmental stages (Shatas & Bystrova, 1954; Emchuk, 1960, 1967), whereas others (humans, larger mammals, including domestic animals) harbour mainly the adults (Shatas & Bystrova, 1954). Domestic hosts reported include cattle, buffaloes, goats, horses, cats and dogs. Because of their abundance, several authors consider hedgehogs and rodents the major hosts for *R. rossicus* (Emchuk, 1960). In rodents and predatory insectivores inhabiting the typical habitats of *R. rossicus*, prevalences of tick infestation may be as high as 80–90% (Shatas & Bystrova, 1954). Despite intensive sample collection during the summer, Kolomietz (1936) failed to find *R. rossicus* on reptiles from Ukraine.

An interesting account of the predilection sites of parasitism in domestic animals was provided by Kolomietz (1936), according to whom the tick, in horses, is found mainly on the inner side of the ear pinna, mane region, tail, chest and inner side of the thighs, whereas in cattle it prefers the ears, udder, perianal region, external sexual organs, chest, neck and flanks. In dogs and cats, ticks were collected mostly from the head and ears, and in pigs *R. rossicus* was found on the ear pinna (Kolomietz, 1936).

*Rhipicephalus rossicus* is a medium-sized tick, slightly larger than *R. sanguineus* s.l. or other related species (i.e. *R. turanicus*). It has strong legs, a more rounded body and is usually of a reddish brown colour. The capitulum is broader than it is long, the palps are short and broad and the eyes are flat. *Rhipicephalus rossicus* can be differentiated from closely related species (e.g. *R. sanguineus* s.l., *R. turanicus*, *R. pumilio*) by: (a) the shape of the adanal plates in males (Fig. 2A), which are very large, posteriorly broad and have a medial spur; (b) the shape of the spiracular plates in males (Fig. 2B), which are short and have broad tails; (c) similarly shaped spiracular plates in females (Fig. 2D), (d) and the extensively broad U-shaped genital aperture in females (Fig. 2C).

## Geographical distribution

The geographical distribution of *R. rossicus* largely overlaps the area covered by the Eurasian steppe (Fig. 3). It has been reported from the countries of Armenia, Azerbaijan, Bulgaria, China, Dagestan, Egypt, Georgia, Iran, Israel, Kazakhstan, Tajikistan, Moldavia, Poland, Romania, Russia, Turkey, Ukraine and Uzbekistan. The limits of its distribution are: 31.3–51.3°N and 23.8–88.1°E. Outside this somewhat compact area of distribution, isolated sites of occurrence include Moscow, Egypt (the Sinai peninsula) and Israel. It is not clear if these isolated reports, which seem to refer to areas outside the species' distribution range, represent misidentifications or accidental occurrences on migrating or introduced hosts.

## Seasonal dynamics

Detailed information regarding the seasonality of *R. rossicus* in Ukraine was provided by Emchuk (1960). Larval and nymphal parasitism was recorded from March (early spring) to November (late autumn), with peaks during June–August (summer). Findings of adults on various hosts occurred all year

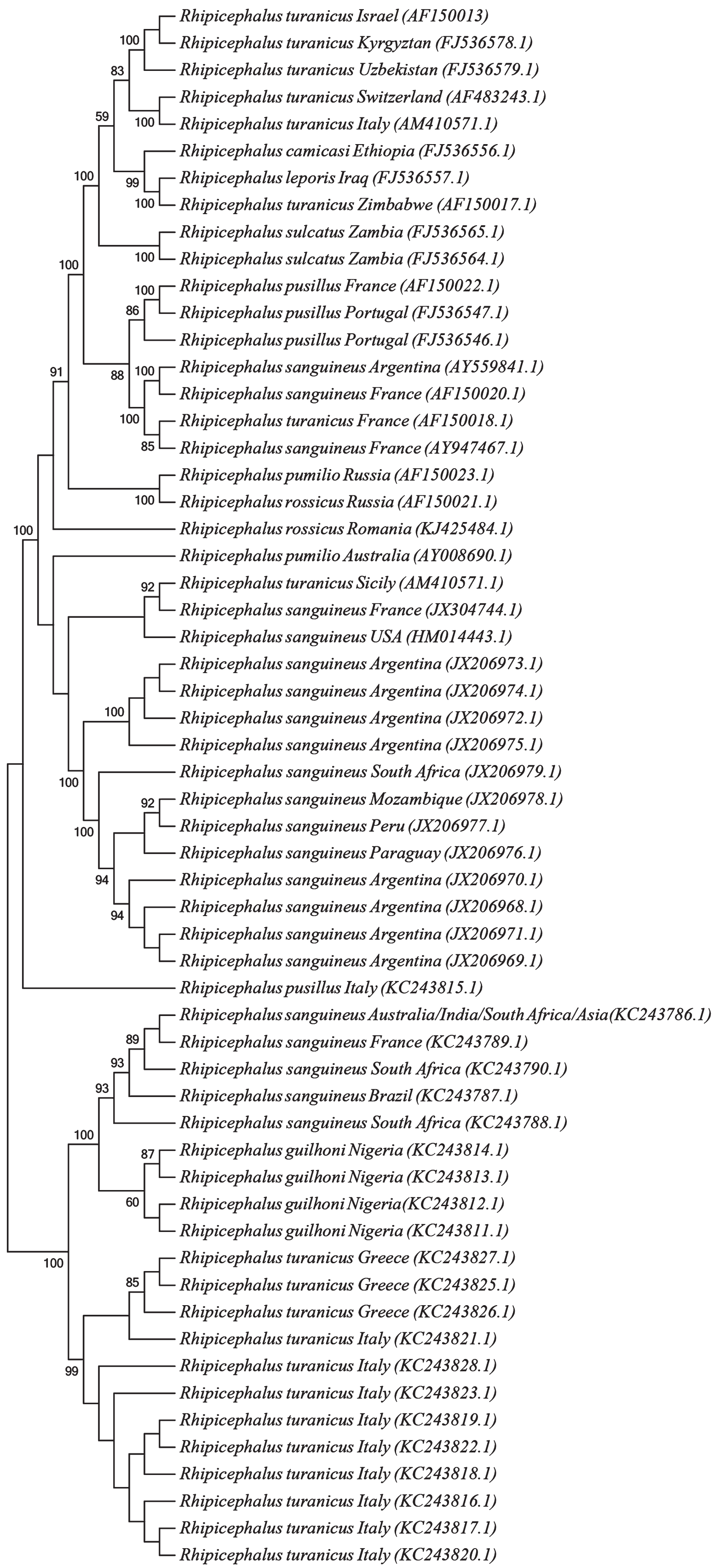


**Fig. 1.** Phylogenetic analysis based on 12S rDNA of species of the *Rhipicephalus sanguineus* group (*sensu* Walker *et al.*, 2000).

**Table 1.** Host spectrum and geographical distribution of *Rhipicephalus rossicus.*

| Host higher taxa | Host | Stage | Country | Reference |
|---|---|---|---|---|
| **Amphibia** | | | | |
| Ranidae | *Rana arvalis* | A | Ukraine | Akimov & Nebogatkin (2013b) |
| **Reptilia** | | | | |
| Lacertidae | *Lacerta agilis* | N, L | Former U.S.S.R. | Filippova (1997) |
| | *Lacerta viridis* | N, L | Former U.S.S.R. | Filippova (1997) |
| **Aves** | | | | |
| Accipitridae | *Circus aeruginosus* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| | *Buteo buteo* | A | Azerbaijan | Gusev *et al.* (1962) |
| Alaudidae | *Calandrella rufescens* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| | *Galerida cristata* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| Fringillidae | *Coccothraustes coccothraustes* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| Emberizidae | *Emberiza hortulana* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| Passeridae | *Passer montanus* | A | Azerbaijan, Ukraine | Gusev *et al.* (1961b), (1962) |
| Paridae | *Parus major* | L | Ukraine | Akimov & Nebogatkin (2013b) |
| Turdidae | *Turdus merula* | L | Ukraine | Akimov & Nebogatkin (2013b) |
| Corvidae | *Pica pica* | A | Azerbaijan | Gusev *et al.* (1962) |
| | *Corvus frugilegus* | A, N, L | Ukraine | Akimov & Nebogatkin (2013b) |
| Phasianidae | *Coturnix coturnix* | ? | Azerbaijan | Gusev *et al.* (1961a) |
| Unknown birds | ? | A | Dagestan, Ukraine | Ter-Vartanov *et al.* (1954) and Vshivkov (1956) |
| **Mammalia** | | | | |
| Canidae | *Canis familiaris* | A, N | Kazakhstan, Romania, Russia, Ukraine | Kulikoff (1935), Pomerantzev *et al.* (1940), Afanas'èva (1960), Emchuk (1960, 1966), Gusev *et al.* (1961b), Mirzoeva (1961), Keirans (1985), Akimov & Nebogatkin (2013b) and Dumitrache *et al.* (2014) |
| | *Canis aureus* | ? | Tajikistan | Chernyshev (1954) |
| | *Vulpes vulpes* | A, N | Russia, Ukraine | Emchuk (1960, 1966), Mirzoeva (1961), Skliar (1970) and Akimov & Nebogatkin (2013b) |
| | *Nyctereutes procyonoides* | ? | Ukraine | Emchuk (1966) |
| Felidae | *Felis catus* | A, N, L | Ukraine | Emchuk (1960) and Akimov & Nebogatkin (2013b) |
| Mustelidae | *Mustela eversmanii* | A, N, L | Ukraine | Kulikoff (1935), Emchuk (1960, 1966) and Skliar (1970) |
| | *Mustela nivalis* | A, N, L | Ukraine | Emchuk (1960) |
| | *Mustela* sp. | ? | Russia | Mirzoeva (1961) |
| Sciuridae | *Spermophilus suslicus* | A, N, L | Ukraine | Emchuk (1960, 1966) |
| | *Spermophilus citellus* | ? | Romania | Feider (1964) |
| | *Spermophilus pygmaeus* | A, N, L | Ukraine | Emchuk (1960) |
| | *Spermophilus* sp. | ? | Russia | Mirzoeva (1961) |
| | *Marmota bobak* | ? | Ukraine | Emchuk (1966) |
| | *Marmota marmota* | ? | Kazakhstan | Afanas'èva (1960) |
| Muridae | *Rattus rattus* | ? | Ukraine | Emchuk (1966) |
| | *Rattus norvegicus* | N | Ukraine | Emchuk (1966), Skliar (1970) and Akimov & Nebogatkin (2013b) |
| | *Mus musculus* | A, N, L | Ukraine | Emchuk (1960, 1966), Skliar (1970) and Akimov & Nebogatkin (2013b) |
| | *Apodemus agrarius* | N | Ukraine | Emchuk (1966) and Akimov & Nebogatkin (2013b) |
| | *Apodemus sylvaticus* | A, N, L | Ukraine | Emchuk (1960, 1966) |
| | *Apodemus flavicollis* | A, N, L | Moldavia, Ukraine | Uspenskaia (1987) and Akimov & Nebogatkin (2013b) |
| | *Apodemus* sp. | ? | Ukraine | Skliar (1970) |
| | *Mycromys minutus* | N | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Meriones tamariscinus* | ? | Kazakhstan | Afanas'èva (1960) |
| | *Rhombomys opimus* | A, N | Iran | Filippova *et al.* (1976) |
| Cricetidae | *Myodes glareolus* | N | Ukraine | Emchuk (1966) and Akimov & Nebogatkin (2013b) |
| | *Cricetus cricetus* | A, N, L | Russia, Ukraine | Emchuk (1960, 1966), Filippova & Panova (1983) and Akimov & Nebogatkin (2013b) |

**Table 1.** Continued

| Host higher taxa | Host | Stage | Country | Reference |
|---|---|---|---|---|
| | *Cricetulus migratorius* | A, N, L | Kazakhstan, Ukraine | Afanas'èva (1960), Emchuk (1960, 1966) and Skliar (1970) |
| | *Microtus arvalis* | A, N, L | Ukraine | Emchuk (1960, 1966), Skliar (1970) and Akimov & Nebogatkin (2013b) |
| | *Microtus socialis* | A, N, L | Ukraine | Emchuk (1960) |
| | *Microtus oeconomus* | N | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Microtus subterraneus* | N | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Ondatra zibethicus* | N, L | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Arvicola terrestris* | N | Ukraine | Akimov & Nebogatkin (2013b) |
| Dipodidae | *Sicista subtilis* | N, L | Ukraine | Emchuk (1960) |
| | *Jaculus jaculus* | A, N | Ukraine? | Emchuk (1960) |
| Erinaceidae | *Erinaceus concolor* | A, L | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Erinaceus roumanicus* | A, N, L | Moldavia, Romania, Russia, Ukraine | Emchuk (1960, 1966), Mirzoeva (1961), Feider (1964), Butenko *et al.* (1971), Uspenskaia (1987) and Mihalca *et al.* (2012) |
| | *Hemiechinus auritus* | A, N, L | Ukraine | Emchuk (1960) |
| Soricidae | *Sorex araneus* | N | Ukraine | Emchuk (1966) and Akimov & Nebogatkin (2013b) |
| | *Sorex minutus* | N | Ukraine | Akimov & Nebogatkin (2013b) |
| | *Crocidura suaveolens* | A, N, L | Ukraine | Akimov & Nebogatkin (2013b) |
| Leporidae | *Oryctolagus cuniculus* | A, N, L | Ukraine | Emchuk (1960) |
| | *Lepus europaeus* | A, N | Azerbaijan, Ukraine | Emchuk (1960, 1966) and Abusalimov (1965) |
| | *Lepus* sp. | ? | Russia | Mirzoeva (1961) |
| | Unknown | ? | Ukraine | Kulikoff (1935) |
| Ochotonidae | *Ochotona dauurica* | A, N | Turkmenistan | Berdyev (1980) |
| Bovidae | *Bos taurus* | A, N | Moldavia, Poland, Russia, Ukraine, Uzbekistan | Pomerantzev *et al.* (1940), Emchuk (1960), Mirzoeva (1961), Dutkiewicz & Siuda (1969), Butenko *et al.* (1971), Uspenskaia (1987), Rasulov (2007) and Akimov & Nebogatkin (2013b) |
| | *Bubalus bubalis* | A | Russia | Pomerantzev *et al.* (1940) |
| | *Capra hircus* | A, N | Egypt, Ukraine | Emchuk (1960) and Feldman-Muhsam (1960) |
| Cervidae | *Cervus elaphus* | A, N | Ukraine | Emchuk (1960) |
| | *Capreolus capreolus* | A | Ukraine | Akimov & Nebogatkin (2013b) |
| Suidae | *Sus scrofa* | A, N, L | Ukraine | Emchuk (1960) |
| Camelidae | *Camelus bactrianus* | A | Ukraine? | Emchuk (1960) and Akimov & Nebogatkin (2013b) |
| Equidae | *Equus caballus* | A | Russia, Ukraine | Pomerantzev *et al.* (1940) and Emchuk (1960) |
| Hominidae | *Homo sapiens* | A | Ukraine, Moldavia, Romania, Russia | Kulikoff (1935), Shatas & Bystrova (1954), Feider (1965) and Uspenskaia (1987) |
| Unknown | ? | ? | Armenia, Bulgaria, Georgia, China, Israel, Turkey, Russia | Pomerantzev (1946), Feldman-Muhsam (1960), Neronov (1974), Keirans (1985) and Chen *et al.* (2010) |

A, adult; L, larva; N, nymph.

round, peaking from April (mid-spring) to July (mid-summer) (Emchuk, 1960). According to Pomerantzev *et al.* (1940), adults are active from April (mid-spring) to September (early autumn). Gusev *et al.* (1962) collected adults from birds in the Kura-Araksinsky lowlands, Azerbaijan in April (mid-spring), June (mid-summer) and November (late autumn). Several authors have reported the maximum peak of activity to occur in June and July (summer) (Shatas, 1956) or May–August (Kolomietz, 1936). Dumitrache *et al.* (2014) found *R. rossicus* on dogs in southeastern Romania from April (spring) to August (summer), with a significant peak in occurrence during May–July. Feider (1965) and Coipan *et al.* (2011) reported adults on rodents and hedgehogs in Romania during May–July, and larvae and nymphs only in July.

## Ecology

Shatas (1956) stated that the typical habitats of *R. rossicus* were 'bottomland valleys and foothill biotopes' and that ticks avoid 'dry habitats'. This preference for river basin valleys was attributed by Shatas & Bystrova (1954) mainly to the richness of available hosts and climate. Emchuk (1967) and Brovko (1969) listed *R. rossicus* as one of the dominant species in dry artificial

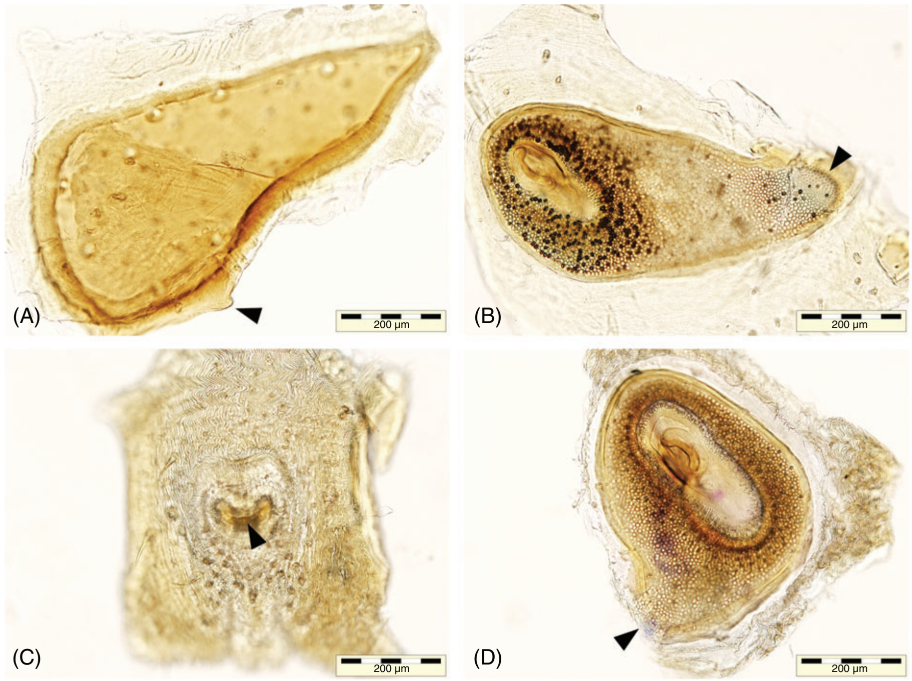


**Fig. 2.** Key morphological features of *Rhipicephalus rossicus*. (A) Adanal plates in males. The arrowhead shows the medial spur. (B) Spiracular plates in males. The arrowhead shows the broad aspect of the tail. (C) Genital aperture in females. The extensively broad U-shape is evident (arrowhead). (D) Spiracular plates in females. The arrowhead shows the broad aspect of the tail.

forests in the steppe zones of southern Ukraine. In Ukraine, the tick is also present in mixed cereal grassland steppe biotopes (Emchuk, 1967). In Transcaucasia, *R. rossicus* was found at altitudes of 40–1112 m a.s.l., in areas with wormwood and grass, lowland liana forests of eastern type, central mountain belts with oak dominance and mountain steppes (Pomerantzev *et al.*, 1940). In the former U.S.S.R. and Romania, *R. rossicus* was found at altitudes of 0–500 m a.s.l. (Feider, 1965). In Bulgaria, Drenski (1955) collected it at 1500 m a.s.l. Kulikoff (1935) found this tick in grasslands, gardens and parks, acacia forests and raspberry bushes.

In a study on the diversity and abundance of ticks from Prikaspiye (in the former U.S.S.R.), *R. rossicus* was listed (together with nine other species) amongst the dominant ticks out of 46 species and subspecies found (Ganiyev, 1966).

With regard to dog parasitism, the most interesting occurrences are those in regions in which *R. rossicus* is sympatric with *R. sanguineus* (Fig. 3). In certain localities in these areas of co-occurrence, *R. rossicus* replaced *R. sanguineus* and was reported to be the dominant tick in dogs, mainly in the summer months (Dumitrache *et al.*, 2014). In other localities, *R. sanguineus* and *R. rossicus* occurred on dogs with comparable frequencies (Sándor *et al.*, 2014). This rather remarkable interspecific competition success of *R. rossicus* over other tick species was also recorded in the past. Following the cold winter of 1968–1969 in Rostov Oblast (Russia), the density of the *R. rossicus* population increased three-fold in 1 year, and this species replaced *Hyalomma marginatum* (Ixodida: Ixodidae) as the tick most commonly found on cattle (Badalov *et al.*, 1971). This was attributed to the increased overwinter survival of *R. rossicus* in comparison with *H. marginatum* (Hoogstraal, 1979). Moreover, it has been suggested that *R. rossicus* can also replace *H. marginatum* in its role as an epidemiological vector (Hoogstraal, 1979).

## Lifecycle

Little is known about the lifecycle of *R. rossicus*. It is a three-host tick, with a natural lifecycle of 2–3 years (Emchuk, 1967; Walker *et al.*, 2000). The relatively long duration of the lifecycle is attributed to the seasonal autonomy of all stages (Belozerov, 1976). The lifecycle was described under laboratory conditions by Kolomietz (1936). Fully engorged females collected from hedgehogs, horses and cattle laid eggs after 5–11 days. Numbers of eggs varied from 200 to 6800 and were correlated with the weight of the females. Larvae hatched from the eggs in 23–26 days. Larvae were experimentally fed on hedgehogs, cats, guinea pigs, dogs and horses. The duration of larval feeding was 1–2 days (Kolomietz, 1936). Pogorelyi (1966) fed larvae using laboratory rabbits and reported the full engorgement and detachment of larvae within 3–5 days. Larvae moulted to nymphs in 8–11 days. The feeding duration of nymphs on experimental animals was 3–4 days. The second moult (nymphs to adults) occurred in 15–20 days. Adults fed on animals for 7–9 days. The total duration of the lifecycle of *R. rossicus* under laboratory conditions was 77–108 days (Kolomietz, 1936). However, Kolomietz (1936) did not provide any information on the temperature and humidity used in his experimental work.

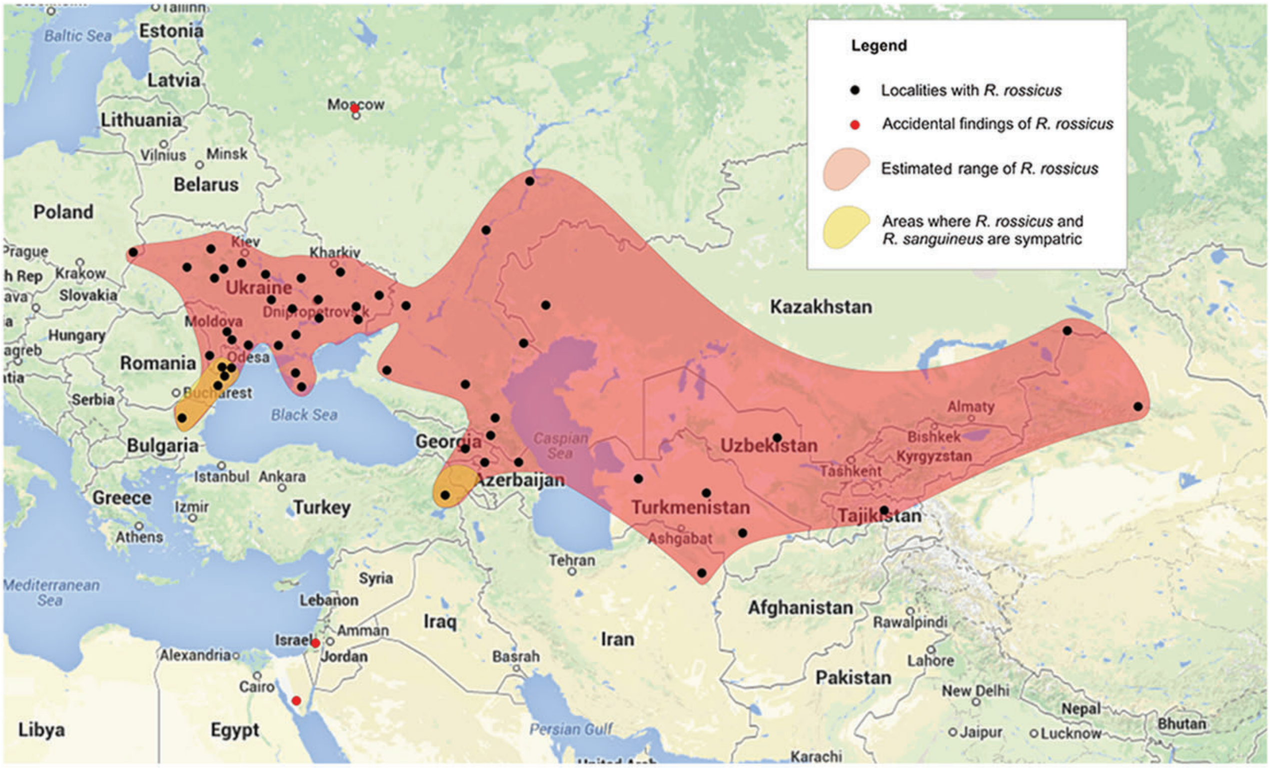


**Fig. 3.** Distribution range of *Rhipicephalus rossicus.*

## Medical importance

The vectorial capacity of *R. rossicus* has been investigated for only a few pathogens. To date, this species has been shown to have vectorial competence for *Francisella tularensis*, Crimean–Congo haemorrhagic fever (CCHF) virus and West Nile virus (WNV). Other pathogens have been occasionally detected in *R. rossicus*, but its vectorial competence for them has not been demonstrated.

### *Tularaemia*

*Rhipicephalus rossicus* is considered to be among the most important vectors for tularaemia in steppe zones and flood-plain valleys of the former U.S.S.R. (Shatas & Bystrova, 1954; Emchuk, 1967). Detections of *F. tularensis* in *R. rossicus* were reported in the Krasnodar region (Strikhanova *et al.*, 1965), Volgograd Oblast (Borodin *et al.*, 1965), Transcaucasia (Armenia), Azerbaijan, the plains of Central Asia and southern Kazakhstan (Neronov, 1974). The reported prevalence of *F. tularensis* in *R. rossicus* was as low as 1.4% (Balashov, 1987).

The first experimental evidence of the vectorial capacity of *R. rossicus* for *F. tularensis* was provided by Shatas & Bystrova (1954). They showed that *R. rossicus* is able to transmit the agent of tularaemia by trans-stadial passage. To date, there is no experimental evidence to indicate the possibility of transovarial transmission of *F. tularensis* by *R. rossicus*. Interestingly, none of the adult ticks infected with *F. tularensis* survived the experimental overwintering, whereas 70% of uninfected control ticks did (Shatas & Bystrova, 1954). This observation might be important if the hypothesis that *F. tularensis* is able to reduce the natural survival of infected ticks is correct.

The significant medical importance of *R. rossicus* as a vector for *F. tularensis* is also related to reservoir hosts which commonly harbour all developmental stages of the tick. Moreover, adult *R. rossicus* can occasionally feed on humans (Shatas & Bystrova, 1954). Olsufev *et al.* (1963) used the absence of *F. tularensis* in *R. rossicus* and *Dermacentor marginatus* (Ixodida: Ixodidae) collected from cattle as proof of the beneficial impact of the Volgograd hydroelectric power station, which they attributed to the reduction in population density of one of the principal reservoir hosts, *Arvicola terrestris*. Borodin *et al.* (1958) reported two human cases of allergic reactions after bites of *R. rossicus* infected with *F. tularensis*. The allergic reaction occurred in subjects vaccinated against tularaemia.

### *Crimean–Congo haemorrhagic fever virus*

The first isolation of CCHF virus from *R. rossicus* was performed by Chumakov (1969) in ticks collected from cattle and sheep. The principal natural reservoirs of CCHF virus (e.g. hedgehogs, hares, ground squirrels) are also important hosts for *R. rossicus*. Hence, the epidemiological role of this tick in the natural cycle of CCHF virus may be significant (Hoogstraal, 1979). Kondratenko (1976) showed the oral vector competence of *R. rossicus* for CCHF virus and proved its vertical transmission. The virus was found in *R. rossicus* collected from cattle and *Erinaceus roumanicus* hedgehogs in Rostov region, western Russia (Casals *et al.*, 1970; Kondratenko *et al.*, 1970; Rabinovich *et al.*, 1970). However, the infection was not detected in *R. rossicus* collected from infected *Hemiechinus auritus* hedgehogs (Hoogstraal, 1979). Butenko *et al.* (1971) isolated the virus from engorged *R. rossicus* males parasitic on cattle in Severskiy District (Krasnodar Krai, Russia) and from engorged females collected from hedgehogs in Belaya Kalitva (Belokalitvinsky District, Rostov Oblast, Russia). Badalov *et al.* (1971) found infection with CCHF virus in *R. rossicus* to originate from *Lepus europaeus*.

### *West Nile virus*

Although no natural infections with WNV were reported in *R. rossicus*, immature stages of *R. rossicus* were experimentally shown to receive, preserve and trans-stadially maintain the virus (Kotel'nikova & Kondrashova, 1974). Moreover, experimentally infected females were able to transmit the infection to larval offspring via the transovarial route (Kotel'nikova & Kondrashova, 1974; Kotel'nikova, 1978). However, so far there is no evidence that *R. rossicus* is involved in the natural transmission cycle of WNV.

### *Other pathogens*

Other pathogens have been sporadically reported from *R. rossicus*, but no further evidence of a vectorial role has been provided. Hence, these associations should be treated cautiously. In 1935, during a mass outbreak of equine theileriosis in Ukraine, horses were found to be massively infested with one single species of tick, namely *R. rossicus* (Kolomietz, 1936). This seems to be the first circumstantial evidence for the possible vectorial role of *R. rossicus* for *Theileria equi*. Kapustin (1955) also reported *R. rossicus* as a vector for *T. equi* and also *Babesia bigemina*. However, no experimental or other types of proof were provided. Hoogstraal (1979) mentioned the association of *R. rossicus* with *Coxiella burnetii*, but provided no reference.

## Conclusions

*Rhipicephalus rossicus*, a species with apparently low host specificity and a distribution range largely overlapping the Eurasian steppe, is a neglected tick. Its distribution range may be more extensive than is currently known as a result of its possible misidentification as *R. sanguineus* because the two species may be difficult to distinguish during routine morphological examination. This situation is particularly likely in the case of ticks collected from dogs in areas where the two tick species are sympatric or where *R. sanguineus s.l.* is typically considered to be the only representative of the genus parasitic in canids.

We consider that the vectorial importance of *R. rossicus* may be significantly higher than is currently recognized, mainly because the closely related species *R. sanguineus s.l.* is known to transmit a very wide spectrum of pathogens. It would be particularly interesting to evaluate this hypothesis in areas in which the two species of tick are sympatric or even co-feed on the same host individuals. The probably underestimated vectorial role of *R. rossicus* may represent a hidden public health threat as this tick is occasionally reported to feed on humans.

## Acknowledgements

ADM was supported in this research by a grant from the UEFISCDI grant PCE 236/2011. MOD's work was financed by POSDRU grant no. 159/1.5/S/136893 grant with title: "Parteneriat strategic pentru creşterea calităţii cercetării ştiinţifice din universităţile medicale prin acordarea de burse doctorale şi postdoctorale – DocMed.Net_2.0". ADM MOD and ZK are members of the COST Action TD1303 "European Network for Neglected Vectors and Vector-Borne Infections (EURNEGVEC)".

## References

Abusalimov, N.S. (1965) Ixodid fauna of birds, wild mammals and domestic animals of Zakatalskii Reserve in Azerbaijan. *Trudy Instituta Zoologii Akademii Nauk Azerbaijan SSR*, **24**, 183–188 (in Russian).

Afanas'èva, O.V. (1960) Ixodid ticks of Tarbagatai. *Trudy Sredne-Aziatskogo Nauchno-Issledovattel'skogo Protivochum Instituta*, **6**, 275–284 (in Russian).

Akimov, I.A. & Nebogatkin, I.V. (2002) Ticks of Kiev – urbozoological and epizootiological aspects. *Vestnik Zoologii*, **36**, 91–95.

Akimov, I.A. & Nebogatkin, I.V. (2013a) Change of urban stations and the diversity of ticks in megalopolis. XV International Conference of the Ukrainian Scientific Society of Parasitologists, 15–18 October 2013, Chernivtsi.

Akimov, I.A. & Nebogatkin, I.V. (2013b) Ticks of the genus *Rhipicephalus* (Acari, Ixodidae) and their distribution in Ukraine. *Vestnik Zoologii*, **47**, e28–e34.

Badalov, M.E., Koimchidi, E.K., Semenov, M.Y. & Karinskaya, G.A. (1971) Crimean hemorrhagic fever in Rostov region. *Trudy Instituta Poliomielita I Virusnykh Entsefalitov Akademii Meditsinskikh Nauk SSSR*, **19**, 167–173.

Balashov, Y.S. (1987) The organism of ticks as a habitat of the agents of arthropod-borne diseases. *Parazitologicheskii Sbornik*, **34**, 48–69.

Beati, L. & Keirans, J.E. (2001) Analysis of the systematic relationships among ticks of the genera *Rhipicephalus* and *Boophilus* (Acari: Ixodidae) based on mitochondrial 12S ribosomal DNA gene sequences and morphological characters. *Journal of Parasitology*, **87**, 32–48.

Belozerov, V.N. (1976) Life cycles and seasonal adaptation of ixodid ticks (Acarina, Ixodidae). Dokl 28 Ezhegodn Chten Pamyati N A Kholodkovskogo, Leningrad.

Berdyev, A. (1980) *Ecology of Ixodid Ticks of Turkmenistan and their Roles in the Epizootiology of Natural Focal Diseases*. Ylym, Ashkhabad (in Russian).

Borodin, V.P., Samsonova, A.P. & Koroleva, A.P. (1958) Two cases of allergic reactions to bites by infected ticks from the family *Rhipicephalus rossicus* in subjects vaccinated against tularemia. *Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii*, **29**, 117–118.

Borodin, V.P., Spitsin, N.A., Samsonova, A.P., Koroleva, A.P., Ermolova, N.D. & Chunikhin, V.P. (1965) Contribution to further study of natural ravine-steppe type tularemia focus in Volgograd. *Oblast Mater Nauch Prakt Konf Tulyarem Soputst Infekts*, 14–16.

Brovko, S.M. (1969) On the ecology and distribution of ixodid ticks in plantation forests of the Ukrainian steppe zone. PhD Thesis (abstract), Akarol Soveshch. Leningrad University (in Russian).

Butenko, A.M., Donets, M.A., Durov, V.I., Tkachenko, V.A., Perelatov, V.D. & Chumakov, M.P. (1971) Isolation of CHF virus from *Rhipicephalus rossicus* and *Dermacentor marginatus* ticks in Rostov Oblast and Krasnodar region. *Viral Hemorrhagic Fevers. Crimean Hemorrhagic Fever, Omsk Hemorrhagic Fever, Hemorrhagic Fever with renal syndrome*, *Trudy Instituta Poliomielita* I *Virusnykh Entsefalitov Akademii Meditsinskikh Nauk SSSR*, Vol. 19 (ed. by M.P. Chumakov), pp. 45–47.

Casals, J., Henderson, B.E., Hoogstraal, H., Johnson, K.M. & Shelokov, A. (1970) A review of Soviet viral hemorrhagic fevers, 1969. *Journal of Infectious Diseases*, **122**, 437–453.

Chen, Z., Yang, X., Bu, F., Yang, X., Yang, X. & Liu, J. (2010) Ticks (Acari: Ixodoidea: Argasidae, Ixodidae) of China. *Experimental and Applied Acarology*, **51**, 393–404.

Chernyshev, V.I. (1954) On the ecology and parasites of the jackal in Tadzhikistan. *Trudy Akademii Nauk Tadzhikskoy SSR Dushanbe*, **21**, 151 (in Russian).

Chumakov, M.P. (1969) Problems of ecology of Crimean Hemorrhagic Fever Virus. Proceedings of the Fifth Symposium on the Role of Migrating Birds in the Distribution of Arboviruses, July 1969, Novosibirsk.

Coipan, E.C., Vladimirescu, A.F., Ciolpan, O. & Teodorescu, I. (2011) Tick species (Acari: Ixodoidea) distribution, seasonality and host associations in Romania. *Travaux du Muséum National d'Histoire Naturelle 'Grigore Antipa'*, **54**, 301–317.

Dantas-Torres, F., Latrofa, M.S., Annoscia, G., Giannelli, A., Parisi, A. & Otranto, D. (2013) Morphological and genetic diversity of *Rhipicephalus sanguineus sensu lato* from the New and Old Worlds. *Parasites & Vectors*, **6**, 213.

Drenski, P. (1955) Săstav i razprostranenie na kărležite (Ixodoidea) v Bălgarija (s ogled na medicinskoto i veterinarnoto im značenie [Artbestand und Verbreitung der Zecken (Ixodoidea) in Bulgarien (im Hinblick auf ihre medizinische und tierärtztliche Bedeutung)]. *Bulletin of the Institute of Zoology (Sofia)*, **4-5**, 109–168 (in Bulgarian with Russian and German summary).

Dumitrache, M.O., Kiss, B., Dantas-Torres, F., Latrofa, M.S., D'Amico, G., Sándor, A.D. & Mihalca, A.D. (2014) Seasonal dynamics of *Rhipicephalus rossicus* attacking domestic dogs from the steppic region of southeastern Romania. *Parasites & Vectors*, **7**, 97.

Dutkiewicz, J. & Siuda, K. (1969) *Rhipicephalus rossicus* Jakimov et Kohl Jakimova, 1911: nowy dla fauny Polski rodzaj i gatunek kleszcza (Acarina, Ixodidae). *Fragmenta Faunistica*, **15**, 99–105.

Emchuk, E.M. (1960) *Fauna of Ukraine*, Vol. 25/1. Akademii Nauk Ukrainskoi SSR, Kiev (in Ukrainian).

Emchuk, E.M. (1966) On the biology of *Rhipicephalus rossicus* Jak. et K.-Jak. *Respublik Mezhvedomstv Sborn Akad Nauk Ukrain SSR Problemy Parazitol*, **6**, 166–173 (in Russian).

Emchuk, E.M. (1967) Landscape distribution of Ixodid ticks and natural focal diseases in Ukraine. Tezisy Dokl Nauch Konf Ukrain Respub Nauch Obshch Parasit, Izd 'Naukova Dumka', Kiev.

Feider, Z. (1964) Les connaissances actuelles sur les acariens de Roumanie (Ixodides, Gamasides et Trombiculides). Proceedings of the First International Congress on Acarology, 2–7 September 1963, Fort Collins, CO, pp. 262–274.

Feider, Z. (1965) *Fauna of the Popular Republic of Romania*, *Vol. 5/2. Acaromorpha, Suprafamily Ixodoidea*. Editura Academiei Republicii Populare Romane, Bucharest (in Romanian).

Feldman-Muhsam, B. (1960) The ticks of Sinai. *Bulletin of the Research Council of Israel, Section B: Zoology*, **9B**, 57–64.

Felsenstein, J. (1985) Confidence limits on phylogenies: an approach using the bootstrap. *Evolution*, **39**, 783–791.

Filippova, N.A. (1997) *Ixodid ticks of subfamily Amblyomminae. Fauna of Russia and neighboring countries*, Vol. 4. Nauka Publishing House, St. Petersburg, Florida.

Filippova, N.A. & Panova, I.V. (1983) Importance of external ultrastructures for systematics of ixodid ticks of the genus *Rhipicephalus* Koch (Ixodoidea, Ixodidae). *Parasitologicheskii Sbornik Zoologicheskogo Instituta Akademii Nauk SSSR*, **31**, 17–36.

Filippova, N.A., Neronov, V.M. & Farhang-Azad, A. (1976) Materials on the fauna of Ixodids (Acarina, Ixodidae) of small mammals in Iran. *Entomologicheskoe Obozrenie*, **55**, 468–479.

Ganiyev, I.M. (1966) Ecological-faunistic investigation on ixodid ticks and the epizootiology of hemosporidioses in farm animals of western Prikasp'ye. PhD Thesis (abstract), Akarol Soveshch. Leningrad University (in Russian).

Guglielmone, A.A., Robbins, R.G., Apanaskevich, D.A. *et al.* (2010) The Argasidae, Ixodidae and Nuttalliellidae (Acari: Ixodida) of the world: a list of valid species names. *Zootaxa*, **2528**, 1–28.

Gusev, V.M., Bedny, S.N., Guseva, A.A., Labunets, N.F. & Bakeev, N.N. (1961a) Ecological groups of birds of Caucasus and their role in the life of ticks and fleas. *Trudy Nauch-Issled Anti-Plague Instituta Kavkaz Zakavkazsk*, **5**, 217–267 (in Russian).

Gusev, V.M., Tiflova, L.A., Guseva, A.A. & Bedny, S.N. (1961b) Notes on fleas and ticks in Askaniya-Nova. *Trudy Nauch-Issled Anti-Plague Instituta Kavkaz Zakavkazsk*, **5**, 268–275 (in Russian).

Gusev, V.M., Guseva, A.A., Petrosian, E.A. & Eigelis, I.K. (1962) The role of birds in the spread of ticks and fleas. *Zoologichesky Zhurnal*, **41**, 905–912.

Hoogstraal, H. (1979) The epidemiology of tick-borne Crimean–Congo hemorrhagic fever in Asia, Europe, and Africa. *Journal of Medical Entomology*, **15**, 307–417.

Kapustin, F.U. (1955) *Atlas of the blood parasites of animals and ticks*. Gasudarstvenoe izdetejlstvo seljskohazjajstvenoi literaturi, Moscow.

Keirans, J.E. (1985) *George Henry Falkiner Nuttall and the Nuttall Tick Catalogue*. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

Kolomietz, J.S. (1936) Zur Frage der Verbreitung und Lebensweise der Zecke *Rhipicephalus rossicus* Yak. Und Koh.-Yak. in der Ukraine. *Zeitschrift für Parasitenkunde*, **8**, 538–541.

Kolonin, G.V. (2009) Fauna of Ixodid ticks of the World. Moscow. http://www.kolonin.org [accessed on 15 January 2014].

Kondratenko, V.F. (1976) Importance of ixodid ticks in transmitting and preserving the Crimean hemorrhagic fever agent in infection foci. *Parazitologiya*, **10**, 297–302.

Kondratenko, V.F., Blagoveshchenskaya, N.M., Butenko, A.M. *et al.* (1970) Results of virological investigation of ixodid ticks in Crimean hemorrhagic fever focus in Rostov Oblast. *Crimean Hemorrhagic Fever* (ed. by M.P. Chumakov), pp. 29–35 Nauch Prakt KonfRostov-na-Donu.

Kotel'nikova, G.M. (1978) Susceptibility of some tick species to West Nile virus. (Dokl Simp Transkont Svyazi Pereletn Ptits Rol' v Rasp). *Arbovirus (Novosibirsk)*, 236–237.

Kotel'nikova, G.M. & Kondrashova, Z.N. (1974) Survival of West Nile virus in *Rhipicephalus rossicus* ticks. *Sborn Nauch Trudy Diagnost Profilakt Virus Infekts*, **16**, 160–164.

Kulikoff, N.S. (1935) Die geographische Verbreitung der Zecke *Rhipicephalus rossicus* Yakimoff und Kohl-yakimoff, 1911. *Zeitschrift für Parasitenkunde*, **8**, 241–242.

Latrofa, M.S., Dantas-Torres, F., Annoscia, G., Cantacessi, C. & Otranto, D. (2013) Comparative analyses of mitochondrial and nuclear genetic markers for the molecular identification of *Rhipicephalus* spp. *Infection, Genetics and Evolution*, **20**, 422–427.

Mihalca, A.D., Dumitrache, M.O., Magdaş, C. *et al.* (2012) Synopsis of the hard ticks (Acari: Ixodidae) of Romania with update on host associations and geographical distribution. *Experimental and Applied Acarology*, **58**, 183–206.

Mirzoeva, M.N. (1961) Materials on ixodidae of Tersko-Kumsky inter-river and adjoining districts of Checheno-Ingushskaja ASSR. *Trudy Nauch-Issled Anti-Plague Instituta Kavkaz Zakavkazsk*, **5**, 287–297 (in Russian).

Morel, P.C. & Vassiliades, G. (1963) Les *Rhipicephalus* du groupe sanguineus: espèces africaines (Acariens: Ixodoidea). *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux*, **15**, 343–386.

Nebogatkin, I.V. (1996) Spontaneous outbreak breeding steppe tick *R. rossicus* Jakimov et Kohl-Jakimova (Ixodidae) in the outskirts of Kiev. *Vestnik Zoologii*, **3**, 65–67.

Nei, M. & Kumar, S. (2000) *Molecular Evolution and Phylogenetics*. Oxford University Press, New York, NY.

Neronov, V.M. (1974) The southern boundary of the tularemia agent in Asia Minor and Central Asia. *Zoologicheskii Zhurnal*, **53**, 1213–1223 (in Russian).

Olenev, N.O. (1928) Determination of ticks of the family Ixodidae Murray of the U.S.S.R. *Doklady Akademii Nauk SSSR*, **16**, 84–96.

Olsufev, N.G., Kucheruk, V.V., Bordodin, V.P., Petrov, V.G. & Uqlovoi, G.P. (1963) Changes of conditions of existence of the natural tularemia focus in the northern area of the Volgo-Akhtubinsk flood-plain area in connection with the construction of the Volgograd Hydroelectric power station. *Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii*, **40**, 127–132.

Pogorelyi, A.I. (1966) Concerning the immunity of animals to ectoparasitic diseases. *Veterinariya (Kiev)*, **6**, 68–75.

Pomerantzev, B.I. (1946) Les tiques (Ixodidae) de la faune de l'U.R.S.S. et des pays limitrophes. *Opredeliteli po Faune SSSR, Izdavaemye Zoologicheskim Institutom Akademii Nauk SSSR*, **26**, 1–28.

Pomerantzev, B.I. (1959) *A translation of Fauna of U.S.S.R. Arachnida*, Vol. 4. No. 2. Ixodid Ticks [Ixodidae]. The American Institute of Biological Sciences, Washington, District of Columbia.

Pomerantzev, B.I., Matkashvili, N.V. & Lotoskii, B.V. (1940) An ecological and faustic outline of Ixodidae ticks occurring in Transcaucasia. *Parasitologicheskii Sbornik Zoologicheskogo Instituta Akademii Nauk SSSR (Leningrad)*, **7**, 100–133.

Rabinovich, V.D., Blagoveshchenskaya, N.M., Butenko, A.M., Zarubina, L.V., Kondratenko, V.F. & Milyutin, V.N. (1970) Virological and serological examination of wild animals and birds in the Rostov Oblast Crimean hemorrhagic fever focus. Oblast Nauchn Prakt Konf, May 1970, Rostov-on-Don.

Rasulov, I. (2007) Ticks status in Central Asia with a special emphasis on Uzbekistan. *Parasitology Research*, **101**(Suppl. 2), 183–186.

Roy, H.E., Roy, D.B. & Roques, A. (2011) Inventory of terrestrial alien arthropod predators and parasites established in Europe. *Biocontrol*, **56**, 477–504.

Sándor, A.D., Dumitrache, M.O., D'Amico, G., Kiss, B.J. & Mihalca, A.D. (2014) *Rhipicephalus rossicus* and not *R. sanguineus* is the dominant tick species of dogs in the wetlands of the Danube Delta, Romania. *Veterinary Parasitology*, **204**, 430–432.

Saratsiotis, A.G. (1981) Étude morphologique et biologique de *Rhipicephalus moucheti* Morel, 1964, groupe de *Rh. sanguineus* (Acariens: Ixodoidea), espèce africaine. *Acarologia*, **12**, 15–24.

Shatas, Y.F. (1956) Larvae and nymphs of some species of the genus *Rhipicephalus* Koch (Acarina, Ixodidae). *Entomological Review*, **35**, 944–955.

Shatas, Y.F. & Bystrova, N.A. (1954) Role of Ixodid ticks in maintenance of natural foci of tularemia. *Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii*, **6**, 55–61.

Skliar, V.E. (1970) On the fauna of Ixodid ticks from southern Donetzk district. *Parazitologiia*, **4**, 524–527 (in Russian).

Strikhanova, E.V., Meleshko, N.S., Timofeev, M.A., Shevchenko, Z.G., Petrova, L.R., Ushmarova, N.N. & Yarov, T.V. (1965) Results of studying natural focality of tularemia in Krasnodar region for 6 years. *Mater Nauch Prakt Konf Tulyarem Soputst Infekts*, 52–56.

Tamura, K., Stecher, G., Peterson, D., Filipski, A. & Kumar, S. (2013) MEGA6: molecular evolutionary genetics analysis version 6.0. *Molecular Biology and Evolution*, **30**, 2725–2729.

Ter-Vartanov, V.H., Gusev, V.N., Bakeev, N.N., Labunets, N.F., Guseva, A.A. & Reznik, P.A. (1954) On the question of transmission of mammalian ectoparasites by birds. *Zoologicheskii Zhurnal*, **33**, 1116–1125.

Uspenskaia, I.G. (1987) *Ixodid Ticks of the Dnestr-Prut Watershed*. Akademia NAUK Moldavskoi CCP, Kişinev.

Vshivkov, F.N. (1956) Evaluation of the role played by wild birds in feeding and transportation of Ixodid ticks in Crimea. *Trudy 2 Nauch Konf Parasitol Ukrain SSR Kiev*, 33–34.

Walker, J.B., Keirans, J.E. & Horak, I.G. (2000) *The Genus* Rhipicephalus *(Acari, Ixodidae): A Guide to the Brown Ticks of the World*. Cambridge University Press, Cambridge.

Yakimov, L. & Kol-Yakimova, N. (1911) Etude des Ixodides de Russie. *Archives of Parasitology*, **14**, 416–425.

Zahler, M., Filippova, N.A., Morel, P.C., Gothe, R. & Rinder, H. (1997) Relationships between species of the *Rhipicephalus sanguineus* group: a molecular approach. *Journal of Parasitology*, **83**, 302–306.

Zumpt, F. (1939) Die Rhipicephalusarten der U.S.S.R., ein Beitrag zur Variabilität in der Sanguineusgruppe. I. Vorstudie zu einer Revision der Gattung Rhipicephalus Koch. *Zeitschrift für Parasitenkunde*, **11**, 400–409.

Accepted 30 November 2014